correlation between samples and the total number M of samples averaged according to the following relationship:

$$M_I^{-1} = \sum_{m=-M+1}^{M-1} \frac{M-|m|}{M^2} c_m, \tag{1}$$

where the correlation coefficient Cm refers to time (from pulse to pulse) or range, and m is an integer indicating the lag. For correlation in sample time, the lags are mT, where T is the pulse repetition time; for sampling in range the lags are m(τL), where τ is the pulse length and L an integer (or a number larger than 1) if the pulse is over sampled in range. The time correlation function depends on the Doppler spectrum width, which is one of the parameters to be estimated. If samples are averaged in range and the radar resolution volume (i. e., pulse volume) is uniformly filled with scatterers, the correlation coefficient is determined by the pulse shape and the receiver filter impulse response as detailed in the book "Doppler Radar and Weather Observations, 2nd edition, R. J. Doviak and D. S. Zrnic, 1993 Academic Press, Inc. San Diego, 562 pp.

As background to the present invention reference is made to the prior art graphical results as set forth in figures FIG. **1**(*a*) and FIG. **2**(*b*). In these figures two methods currently in use are depicted. In one method, FIG. **1**(*a*), an analog matched filter in the intermediate frequency (IF) stage is used. After detection, digital conversion at arate of about τ^{-1} is made to obtain the complex signal. Two or more estimates of variables from these samples are averaged along the selected range and thus a gain of two or more independent samples as shown in FIG. **1**(*a*) is achieved. In the second method,(FIG. **1**(*b*)), the analog matched filter is omitted and the IF signal is digitized. The second method passes the signal through a digital matched filter; this filter can be placed before the synchronous detector, as FIG. **1**(*b*), or after; then estimates of correlations, spectral moments and polarimetric variables are made; these estimates are averaged in range over a few pulses (i. e., few durations, as shown in FIG. **1**(*b*). Either of the methods in FIG. **1**(*a*) or FIG. **1**(*b*) graphically increases the number of independent samples but not to the fullest extent possible; both procedures sacrifice range resolution.

The first method is used, for example, on the national network of weather radars (WSR-88D). Sampling in range is at 1.67 micro seconds (250 m), several samples are averaged in time and then four samples are averaged in range to decrease the variance and provide a 1 km range resolution. The second method is used on the Sigmet RVP7 receiver and processor.

FIGS. **2**(*a*)–**2**(*c*) depict a sampling in range and the processing of signals according to the prior art. The proposed method of the present invention is depicted in FIGS. **2**(*d*)–**2**(*f*). FIG. **2**(*a*) is a graph depicting transmitted pulses of duration τ and the pulse repetition time T for a transmitted pulse sequence. FIG. **2**(*b*) shows samples in range with spacing equal to the pulse length and the standard processing to obtain the Doppler spectrum and its moments. FIG. **2**(*c*) shows the Doppler spectrum and its moments. FIG. **2**(*d*) is a graph of the over sampling in range. In FIG. **2**(*e*), a zoomed presentation is shown of range locations (over sampled) at which Doppler and polarimetric variables, including spectra, are estimated. Range samples in this figure which are to be whitened (decorrelated) are indicated. The last figure, FIG. **2**(*f*), is a graph of the processing of whitened samples to obtain independent estimates of spectra, spectral moments, and polarimetric variables, in range.

It is an objective of the present invention to provide an improved method which increases the number of independent samples while the sacrifice in range resolution is minimal. FIG. **3** is a flow block diagram of the method steps of the present invention which partially uses conventional prior art method steps. The digital in-phase signal (I) and quadrature phase (Q) components of the signal are supplied at a rate faster than τ^{-1}, (1 MHz for a 1 μs pulse), say Lτ^{-1} (a reasonable L is from 4 to 10), and the receiver bandwidth B is much larger (up to 10 times) than τ^{-1}, and larger but comparable to τ^{-1}. If the system is incoherent and reflectivity or spectrum widths are estimated, then echo power samples would be digitized and processed. The signals are split into two channels. The traditional or prior art processing takes place in the upper block or channel **1** and involves the digital matched filter and classical spectral moment estimation methods. In channel **2**, the signals are processed according to the methods of the present invention.

The proposed new method entails whitening in range the over sampled signals, processing of time samples by any one of the well known algorithms, and combining the results from the whitened signals in range to yield significant reduction in variances of the estimates. This variance reduction occurs only if the signal to noise ratios are relatively high (greater than 15 dB) as is usually the case for most signals in weather surveillance radars. At low signal to noise ratios (less than 10 dB) the variances increase so that there are crossover points (these are different for different estimates) of the variances for the conventional and proposed estimators. Below the cross over SNR (signal to noise ratio), the classical processing produces lower variances. In general the cross over SNR depends on the variable that is to be estimated and on some other parameters (e.g., spectrum width, number of samples, etc.). An objective decision on which estimates to use, classical or the ones obtained from using the method of the present invention, from whitened samples in range, is based on the SNR and on estimates of other parameters that affect the variance. To avoid parallel computation, the choice of which channel to use can be made from an a priori knowledge of the SNR, or data may be stored and processed in the appropriate channel after the SNR has been determined. Alternatively, both processing in channels **1** and **2** proceed simultaneously and the decision on which one to use can be made at the end of the dwell time.

The procedure starts with over sampling in range so that there are L samples during the pulse duration τ (that is over sampling is by a factor of L). Sample spacing need not be uniform for application of this procedure; however uniform sampling is assumed for simplicity. The bandwidth of the system under consideration (radar, sonar, sodar, blood flow acoustic meter, etc.) up to the sampling circuits should be larger than L/τ, (modifications on how to apply the procedure to arbitrary band widths are indicated later). Assume that the range of depth cτ/2 (where c is the velocity of light, or sound in the sonar case) is uniformly filled with scatterers. For relatively short pulses this is a common occurrence. For convenience, the contribution from the pulse volume to the sampled complex voltage V_k (n)=I_k(n)+jQ_k (n) at a fixed time delay (also called range time, indicated by the index k), can be decomposed into sub contributions s_i from L contiguous slabs each cτ/2L thick. The index n indicates time at pulse repetition increments T, also called sample time. The voltages s_i are identically distributed complex Gaussian random variables, the real and imaginary part [Re (s_i) and Im (s_i)] have variances σs^2, and the power of s_i is σ^2=2 σ_s^2. Pulse of an arbitrary shape p_k (k are time increments within